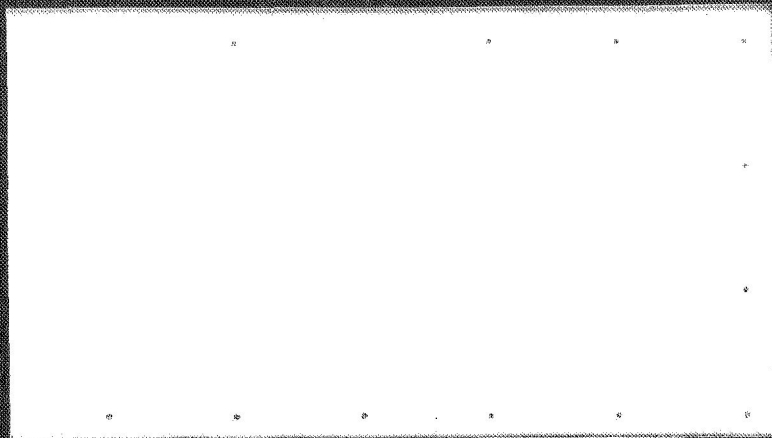


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SEMIANNUAL PROGRESS REPORT
STUDY OF SPACE CABIN ATMOSPHERES
NASA RESEARCH GRANT NGR-22-007-053
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by
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During this report period, major effort was devoted to aerosol measurements carried out in conjunction with the McDonnell-Douglas Sixty-Day Space Cabin Simulator Test. Other activities included further investigation of the hot-wire droplet sensor, theoretical studies to optimize the detector geometry of the NASA-ERC Aerosol Particle Analyzer (APA), and an initial review of the application of a laser-holograph to aerosol studies. Consultation and technical support were also provided at the request of NASA-ERC. A summary of these accomplishments is presented below.

1. McDonnell-Douglas Sixty-Day Space Cabin Simulator Test

During the McDonnell-Douglas Sixty-Day Space Cabin Simulator Test, extended particle studies were made to obtain information on the variations in airborne dust concentrations with time in a closed space cabin environment, as well as to provide insight into the chemical and physical constituents of the ambient aerosol. In addition, the operational compatibility of several possible flight instruments was investigated. It was considered that this test would provide operational experience in planning and conducting space flight experiments such as the T003.

A previous study on the Langley Integrated Life Support System (ILSS) by NASA-ERC, although limited

in scope, provided some information on aerosol levels expected and gave some indication of possible operational difficulties. Even though these studies fall short in their representation of actual flight conditions (for example, zero gravity cannot be simulated), the tests provide valuable insight on the number, size, and composition of airborne particulates which might be dispersed during manned-space flight, and base line data which is otherwise not available.

Two air sampling regimes for particulates were carried out during the Simulator test. The Aerosol Particle Analyzer was used to sample at four locations, four times each day. The location and sampling times were chosen to provide maximum information on the effect of cabin operations on aerosol generation. These measurements were made by the test crew and the results were entered directly in separate logs. These instantaneous or grab sample measurements with the Aerosol Particle Analyzer were supplemented by a time-integrated air sampling system. In this system, a three-hour membrane filter air sample was obtained every other day at a single location using a battery powered sampling pump (Mine Safety Appliances Co., Monitair Sampler). These membrane filter samples were returned to NASA-ERC and counted at the Harvard School of Public Health. Air concentrations were

calculated based upon the particle count, sampling rate, and sampling time. To roughly estimate air-borne particle sizes, the membrane filters were counted by light microscopy at two different magnifications. This procedure permitted counting all particles larger than 1.0 micron at the lower magnification while the higher power permitted detection of all particles with sizes greater than 0.6 micron. These data are summarized in Table 1.

Table 1

Membrane Filter Data, McDonnell-Douglas Test

| | Concentration, thousands of particles per cubic feet. | |
|---------|--|-----------------------|
| | <u>>1.0 micron</u> | <u>>0.6 micron</u> |
| Range | 6.5 - 61.4 | 14.4 - 112.7 |
| Average | 18.9 | 46.8 |

The data presented in Table 1 indicate the general cleanliness of the cabin environment and correspond to a Federal Standard #209 Class 100,000 white room installation.

Data obtained from the Aerosol Particle Analyzer showed significant hourly variations in dust concentrations. In many cases, peak concentrations could be traced to a specific operation being conducted in the Simulator. In general, the APA data paralleled

the data from the membrane filter samples. Both techniques showed little or no decrease in concentration with time.

The variation in concentration of the different particle size fractions identified by the APA did not reveal close coupling between size fractions. In a non-gravity environment, close coupling would be expected since aerodynamic characteristics dependent on weight and thus size would be non-existent.

The Thermal Control and Air Distribution Sub-System in the Simulator was fitted with a fiberglas air filter which collected a significant amount of dust during the Sixty-Day Test. By assuming that this deposit was representative of the airborne dust in the Simulator, it was possible to use it to determine the chemical composition of the airborne dust.

Of the deposited dust, approximately 15 percent was found to be siliceous. Silica could originate from any of the fiberglas materials present such as bedding covers, equipment covering, or the Beta-cloth garments worn by the test crew. Microscopic examination of the filter deposit revealed a significant amount of 5 micron fibers which are characteristic of the basic fiber of the Beta cloth so that at least some of the airborne material originated from the Beta-cloth garments. In addition to the siliceous

materials, approximately 15 to 25 percent of the deposit on the filter was found to be skin scales. The skin scales were identified by analyzing the sample of the filter cake for Urocanic acid. Urocanic acid is unique to mammalian skin and its concentration in skin is well known. A brief summary of the composition of the dust collected on the fiberglas filter is shown in Table 2.

Table 2

Composition of Dust Collected On Filter Taken From
Thermal Control and Air Distribution Sub-System

| <u>Material</u> | <u>Percent</u> |
|--------------------------|----------------|
| Moisture (loss at 110°F) | 9 |
| Ash (muffle at 550°C) | 32 |
| Siliceous 15 | |
| Balance 17 | |
| Skin Scales | 15-25 |
| Volatiles | 34-44 |

The aerosol studies described were the basis for the following papers presented by NASA-ERC and Harvard School of Public Health investigators.

E. Rosenblum, W. A. Burgess, P. C. Reist, and L. Long, "A Family of Portable Versatile Aerosol Particle Analyzers." Presented at the 3rd Annual Meeting of the Association for the Advancement of Medical Instrumentation, Houston, Texas (May 1968). (To be published in the JAAMI, January 1969)

W. A. Burgess, A. L. Lavery, P. C. Reist, and W. Z. Leavitt, "Aerosol Measurement in Closed Space Cabin Systems," presented at the 1968 Aerospace Medical Association Annual Meeting, Miami, Florida (May 1968). (Published in the Proceedings)

A final report on the McDonnell-Douglas Space Cabin Simulator will be published in November 1968.

2. Hot Wire Droplet Sensor

Laboratory studies of the hot-wire sensor continued during this report period with major emphasis given to the calibration of the device and a determination of its performance characteristics. The studies were carried out using a water droplet aerosol generated by a Mistogen EN-140 Ultrasonic Generator. A DISA Hot Wire Anemometer Probe with a 5 micron element was used as the sensor. Pulse information from the hot wire was fed to an oscilloscope and 16 mm movies were made of the oscilloscope display. Area and height measurements of individual pulses were carried out.

The aerosol was sized indirectly using a 0.1 percent sodium chloride solution as the aerosol material. The dried aerosol was collected and electron photomicrographs were sized to determine the distribution of the dried particulate. From this distribution data, the size distribution of the parent droplet aerosol was calculated. The

count median diameter of the test aerosol was found to be 4.1 micron with a standard deviation of 1.6. The droplet concentration was approximately 10^7 droplets per liter.

It was observed that at an air velocity over the probe of 40 cm. per second and a wire temperature of 131°C , the degree of dispersity of the water droplet aerosol based on measuring pulse areas was found to agree closely with that calculated from the sodium chloride measurements implying a rough calibration.

Unfortunately, it appears that wire temperature does affect detector output somewhat, contrary to what had been deduced by previous investigators. Whether this effect negates use of the device for droplet measurement is still to be determined.

A detailed account of this work was included in the following paper by the investigators.

P. C. Reist and W. A. Burgess, "Calibration of a Heated Wire Anemometer," presented at the American Industrial Hygiene Conference, St. Louis, Missouri (May 16, 1968). (Paper has been submitted to the JAIHA)

3. Application of Holographic Techniques to Aerosol Research

The availability of a Technical Operations holograph system at NASA-ERC prompted a review of those areas in aerosol research in which this technique might be useful. The work carried out during

this report period was quite exploratory in nature. This work will be continued during the next report period as a portion of a graduate student's doctoral program.

4. Calculation of Optimum Scattering Geometries for Particle Detectors

In designing light scattering particle detectors, the choice of a good scattering geometry is largely guesswork. Some theoretical computations for several detector geometries and various particle refractive indices have been made by other investigators using Mie theory, but the complexity of the computations has until recently precluded general optimization calculations.

By using a computer program for calculating light scattering according to the Mie theory, we plan to carry out these optimization calculations, considering various light sources, as well as various detector geometries. Development of this information will aid in future modifications to the APA series of particle detectors.

Figures 1a and 1b show the two general geometries which can be considered for light scattering particle detectors. The first case is the so-called central dark stop geometry, while the second is the hollow cone geometry.

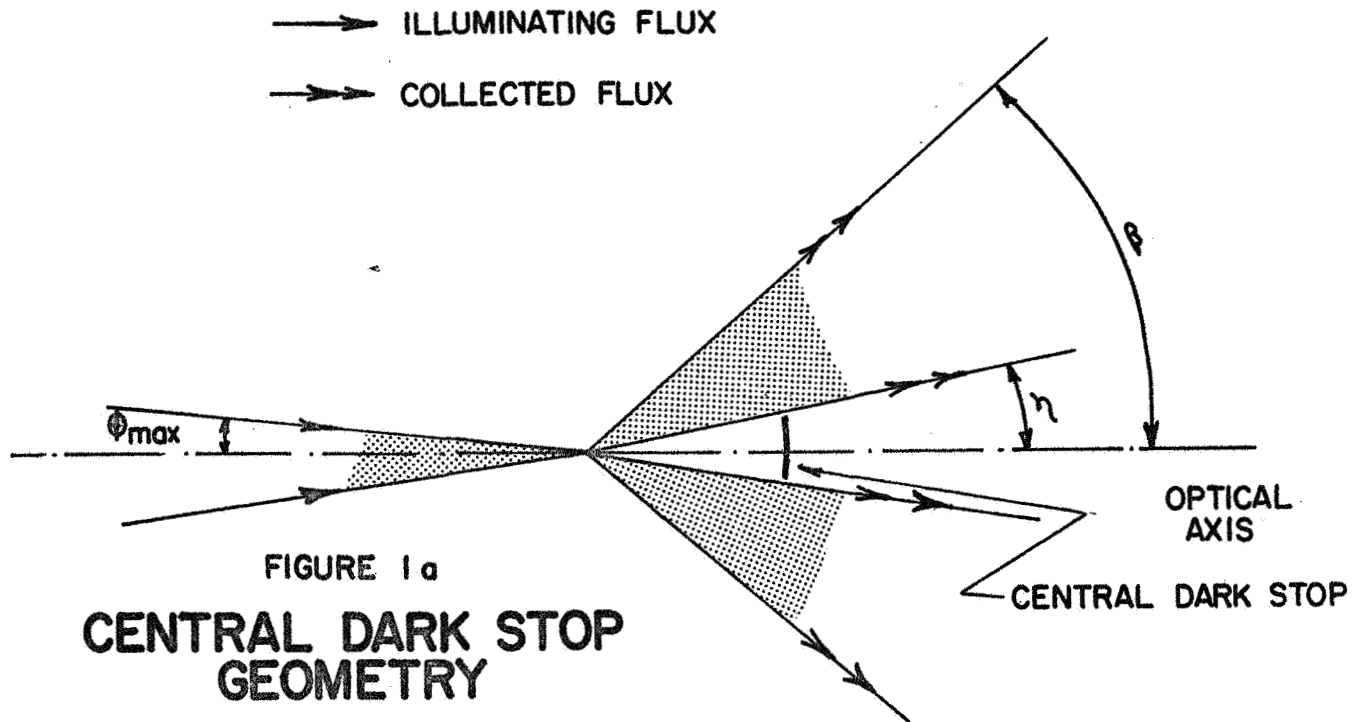


FIGURE 1a
**CENTRAL DARK STOP
GEOMETRY**

RANGE OF θ COLLECTED

$$\eta - \phi_{max} \leq \theta < \beta + \phi_{max}$$

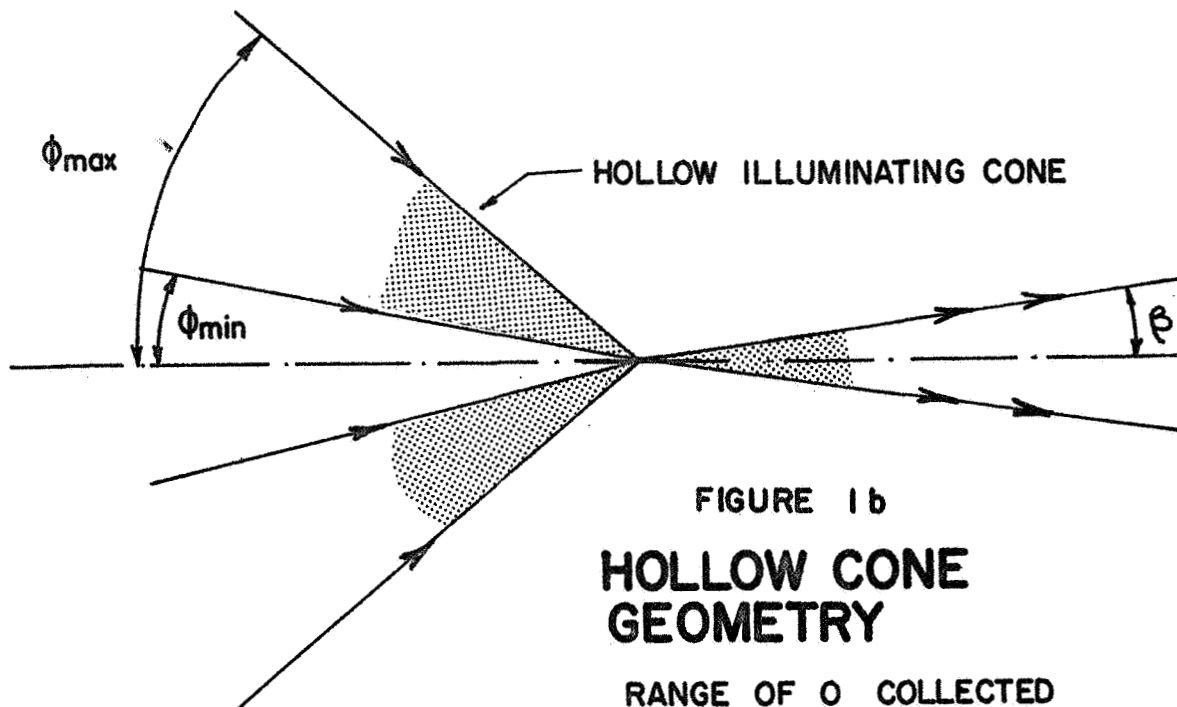


FIGURE 1b
**HOLLOW CONE
GEOMETRY**

RANGE OF θ COLLECTED

$$\phi_{min} - \beta \leq \theta < \phi_{max} + \beta$$

Figure 2 shows the apparent reciprocity between the two geometries for transparent particles of refractive index 1.6. This figure indicates that the two geometries are comparable, although the central dark stop configuration may be more desirable because it transmits, on the average, about 5 times more light than the hollow cone configuration.

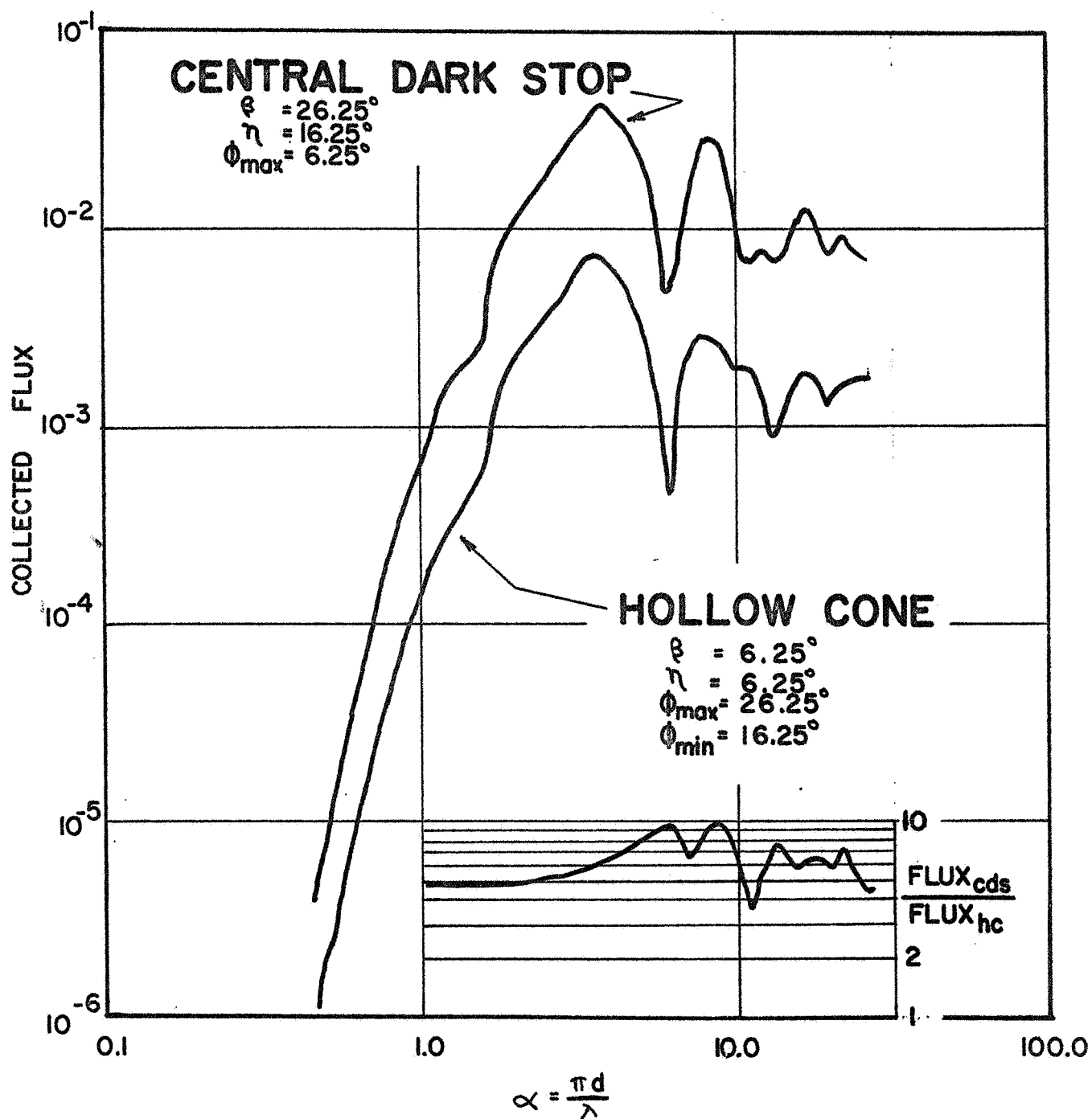
(The above effort was carried out by Mr. James Draper, consultant to the grant.)

5. Future Activities

The major research areas presently underway will be continued including the study of the holograph for aerosol applications, study of the size distribution of calibrating aerosols using both light scatter and hot wire sensors with pulse height conditioning circuits developed at NASA-ERC, a publication of a final report on the McDonnell-Douglas Space Cabin Simulator Study, and the application of a hot wire detector to condensation nuclei counters.

Future effort in optimizing the geometry of the APA series includes comparison of dark field and dark stop geometries for several other indices of refraction including at least one case for absorbing spheres, and then optimizing the design by varying

FIGURE 2
COMPARISON OF
COLLECTED FLUX vs. α



β , η , and ϕ_{\max} . In addition, some work is planned on certain other specific light scattering problems.